ago and called by a less provincial name, the "Pomologie Française."

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SPECIAL ARTICLES

COMPARISON OF THE CATALASE CONTENT OF THE BREAST MUSCLE OF WILD PIGEONS AND OF BANTAM CHICKENS

It is now generally accepted that the energy for muscular work is derived from oxidation of the food materials, although physiologists are not agreed as to the means by which the body accomplishes this oxidation at such a low temperature as 39° C., the temperature of the body.

The present investigation was carried out to determine if catalase, an enzyme which liberates oxygen from hydrogen peroxide or from an organic peroxide comparable in structure to hydrogen peroxide, is greater in amount in the breast muscles of wild pigeons accustomed to flying than it is in the breast muscle of bantam chickens not so accustomed; if the catalase content of the breast muscles of the pigeons would be decreased by decreasing the amount of work done by these muscles, and if it would be increased in the breast muscles of the chickens by increasing the amount of work done.

After several wild pigeons and bantam chickens had been washed until free of blood by the use of large quantities of 0.9 per cent. sodium chloride, as was indicated by the fact that the wash water gave no test for catalase, the breast muscles were removed and ground up separately in a hashing machine. One gram of this material was added to 50 c.c. of hydrogen peroxide in a bottle at 22° C., and as the oxygen gas was liberated it was conducted through a rubber tube to an inverted burette previously filled with water. After the volume of oxygen gas, thus collected in ten minutes, was reduced to standard atmospheric pressure the resulting volume was taken as a measure of the amount of catalase in the gram of material. It was found that one gram of the breast muscle of the wild pigeons liberated on an average, 98 c.c. of oxygen, while that of the bantam chickens liberated only about 8 c.c., hence, the amount of catalase in the breast muscle of the wild pigeons is much greater than that of the bantam chickens.

Several wild pigeons were confined for three weeks in individual small cages so that they could not use their breast muscles in flying, while several bantam chickens were made to run and fly until they were almost exhausted once a day for fifteen days. The catalase of the breast muscles of these pigeons and chickens was determined as in the preceding. It was found that confinement decreased the catalase content of the breast muscles of the pigeons by about 40 per cent., while exercise increased that of the breast muscles of the bantam chickens by almost 25 per cent.

The fact that an increase or decrease in the amount of work, and hence in oxidation in a muscle, is accompanied by a corresponding increase or decrease in the amount of catalase, would seem to suggest that catalase may play a rôle in the oxidative processes of the body.

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CILIA IN THE ARTHROPODA

That cilia are absent in the Arthropoda is an assumption which has crept into our zoological literature. Thus, Adam Sedgwick in his "Student's Text-Book of Zoology," Vol. III., 1909, pp. 316–317, says: "These ducts in the female[1] retain a ciliated lining (Gaffron), the only known instance of the occurrence of a ciliated tract among the Arthropoda." Then again, we read in Parker and Haswell's "Text-Book of Zoology," Vol. I., (revised edition), 1910, p. 526, as follows: "Arthropods are also characterized by the almost universal absence of cilia." Kingsley, on page 357 of his revised edition of Hertwig's "Manual of Zoology," 1912, makes the following assertion concerning cilia in the Arthropoda: "The entire absence of cilia is noteworthy. Ciliated cells have never been found in arthropods." Still another zoologist, J. Arthur Thomson in the fifth, revised edition of his

[1] Sedgwick is discussing ducts in the female reproductive organs of *Peripatus*.

"Outlines of Zoology," 1913, makes a similar remark. Thomson, in speaking of the characteristics of the Arthropoda, on page 281, says: "Ciliated epithelium is almost always absent."

While working on the structure of the male reproductive organs of certain Decapoda,[2] the author has found good examples of ciliated epithelium in the vasa deferentia of the following forms: the Pacific coast crayfish *Astacus leniusculus,* the Puget Sound hermit crab *Pagurus setosus,* the Atlantic coast lobster, *Homarus americanus,* and the spiny lobster of the California coast, *Panulirus interruptus.*

The vasa deferentia of these crustacea were fixed in various fluids (Hermann's, Flemming's, Bouin's and formaldehyde), and the section were cut 5 μ in thickness. These prepared sections formed the basis for the observations herein recorded. The author tried to tease out the living epithelial cells from the vas deferens of *Astacus leniusculus* in physiological salt solution, Ringer's solution as well as in the body fluids of the crayfish, with a view towards observing ciliary movement in the living cells, but along this line of experimentation little success was met with. In the first place, the heavy secretions of the vas deferens, coupled with the refraction of the cell structures, masks any clear-cut observations. Secondly, the cytoplasm of the epithelial cells is so frail that it goes all to pieces upon the application of the least amount of pressure. The writer had, therefore, to rely solely on the prepared slides. However, these epithelial cells are so distinctly and so characteristically ciliated in the fixed material, that they are very convincing and appear to allow of no other interpretation.

In all the forms mentioned the inner lining of the vas deferens consists of a layer of ciliated epithelium, which is made up mainly of columnar cells. This epithelium is more or less glandular in nature and manufactures a thick, viscid secretion that forms the spermatophoral pouches as well as the sperm-preserving fluid which is commonly found in the Decapoda.

In *Astacus leniusculus* the epithelial lining is more or less uniform throughout the vas deferent tube, while in the other forms it becomes somewhat modified.

In *Paragus setosus,* the epithelial cells become concentrated at one pole of the vas deferens and here they are very much elongated, columnar cells and bear fine examples of cilia. This region of the epithelium seems to be especially adapted for manufacturing the secreting fluid. The lining epithelium of the rest of the vas deferens tube consists of ciliated cuboidal cells.

In *Homarus americanus* the epithelium becomes convoluted in numerous places of the distal end of the vas deferens, thus affording a larger secreting surface. Wherever these convolutions occur, the cells are usually larger, and contain longer cilia than in other regions. Herrick[3] who has made an extensive study of the lobster does not mention ciliated epithelium in the vasa deferentia. In good preparations, the ciliated epithelium is so distinct that one is able to make clear microphotographs of these structures without any difficulty.

In the spiny lobster *Panulirus interruptus,* the finest examples of ciliated epithelium were found. In this crustacean the vas deferens is very long and is lined by an inner layer of ciliated columnar epithelial cells. At one point in the vas deferent tube this epithelial lining dips inward into the cavity of the tube and becomes profusely convoluted into a mass of simple tubular glands. In cross sections, some of these glands may be seen cut across to show the central lumen completely surrounded by the epithelial cells. In such cases, the long cilia are very distinctly seen extending from the free surfaces of the cells into the interior of the lumen.

2 A fuller account of these studies is soon to appear in the publications of the Puget Sound Marine Station, Vol. No. 26, under the title of "Male Reproductive Organs of Decapoda, with Special Reference to Puget Sound Forms."

3 Herrick, F. H., "Natural History of the American Lobster," Bull. U. S. Bur. of Fisheries, Vol. XXIX., 1909.

The cilia described in these Decapoda conform in every respect to all authentic descriptions and pictures of cilia which have come under the writer's observation. In many cases, they are short and straight. In other instances they are long and wavy. In still other examples they cluster together to form the so-called brushes. Furthermore, the cilia in all the cases mentioned spring from a well-defined border, and also contain the characteristic basal granules.

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RHYTHMIC BANDING[1]

THE formation of Liesegang's rings, known sometimes as "rhythmic banding," is of interest to the geologist and biologist as well as to the chemist. The color arrangement of agate is an excellent example of this phenomenon. Liesegang's original experiments dealt with the rhythmic precipitation of silver dichromate in gelatine. A solution of silver nitrate was poured on a solid gel containing dilute potassium dichromate. The precipitate of silver dichromate formed was not continuous but marked by gaps or empty spaces at regular intervals.

I found it possible to obtain distinct banding of silver dichromate in loosely packed flowers of sulphur. From this and other experiments it is evident that a gel is not absolutely necessary. In practise I found the best medium for sharply marked bands to be silicic acid gel. With this I secured remarkably crystalline banding of mercuric iodide, as many as forty bands in a test tube. Reduced gold in red, blue and green colloidal particles recurring in regular rainbow bands was obtained with a special silicic acid gel.

Basic gels made it possible to secure bands of cupric hydroxide merging into red and yellow forms of cuprous oxide. In a silicic acid gel of slightly basic reaction crystalline basic mercuric chloride formed in very distinct bands. The best banding in the absolute clearness of the gaps was that of copper chromate in a slightly basic gel.

Upon these experiments a new theory may be built. For illustration consider the copper chromate banding.

The gel contains a dilute solution of a chromate and above it in the tube a solution of a copper salt. The copper ions diffuse into the gel, meet the chromate ion and form a layer of insoluble copper chromate at the surface of the gel. The chromate ions immediately below this precipitation zone diffuse into this region now depleted of chromate ions and meet the advancing copper ions thus thickening the layer of copper chromate. According to Fick's law of diffusion the rate of diffusion is greatest where the difference in concentration of the chromate ions in two contiguous layers is greatest, that is, just below the front of this thickening band of copper chromate. As a result the region near the band decreases in concentration of the chromate ions faster than the space below. Finally the copper ions have to advance some distance beyond the band to find such a concentration of chromate ions that the solubility product of copper chromate may be exceeded and a new band formed. This repeats again and again. Of course if the copper ions were retarded sufficiently there would be time for the concentration of the chromate ions again to become uniform throughout the remaining clear gel and no gap would occur. Hence if the diffusion of the copper ions is retarded by any means the clear gaps decrease in depth—the bands are closer together. If copper ferrocyanide bands are formed in similar manner they almost merge after the first layer reaches a thickness of a few cubic centimeters. Yet they are distinct and agate-like. A precipitate of copper ferrocyanide greatly retards the diffusion of the ions that form it, hence we have here the proper condition to reduce the clear gaps to a minimum depth.

The complete paper with working directions and a full exposition of the theory will soon be published elsewhere.

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[1] Abstract of paper read at the Kansas City meeting of the American Chemical Society, April 12, 1917.